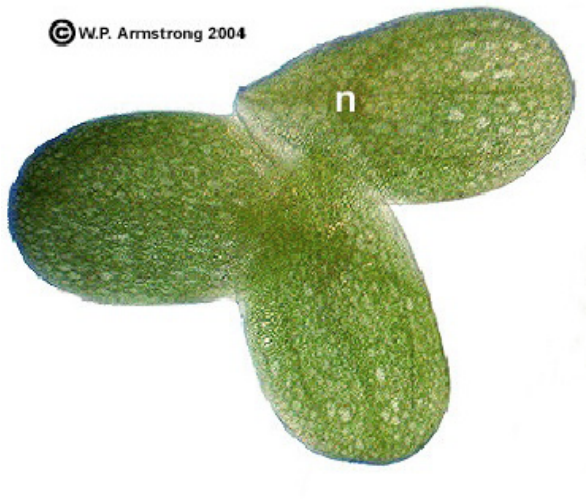
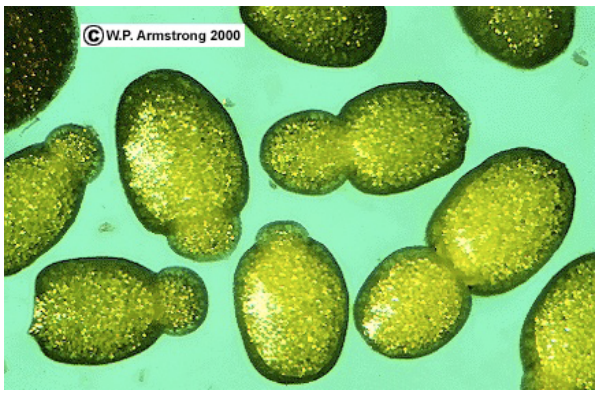
Population Growth and Competition

Background

In order to survive and reproduce, individual organisms take up and transform resources from their environment. When resources are abundantly available, it's like Gershwin's *Summertime,* and "the livin' is easy." Under these conditions, most individuals will survive and reproduce and the population will grow. However, when the resources become limited, **resource competition** can result, which can slow, or even cease, the growth of populations. Resource competition can occur among individuals of the same species (intraspecifically) or of different species (interspecifically), as long as both species utilize the same set of resources.

In this exercise, we will be examining population growth and competition in two species of small floating plants in the duckweed family, *Lemnaceae*. The duckweeds *Lemna minor* and *Wolffia borealis* are small, but they are indeed flowering plants, or Angiosperms. In fact, the *Lemnaceae* are monocots, like grasses, onions, and lilies.





Lemna *Wolffia*

Natural History

Duckweeds commonly inhabit ponds and lakes, especially environments that are free from strong currents or waves. As a consequence of their free-floating lifestyle, all of the duckweeds are small, because they rely on the surface tension of water to keep them on the surface and in the sun.

Like all Angiosperms, the duckweeds have leaves with a highly developed vascular system, and they can make flowers. However, many of the typical plant organs have been modified substantially, or reduced to the point of absence. For example, while most plants array their stomata on the lower leaf surface, the duckweeds carry theirs on the top. Duckweed roots are also a bit different. *Lemna* extends one short root to absorb nutrients dissolved in the water column, while *Wolffia* has no roots at all and absorbs nutrients directly through its leaves. Unlike most Angiosperms, duckweeds reproduce in an almost exclusively asexual fashion. Another way to say this is that almost all of their resources are allocated to vegetative growth. New individuals are produced from buds forming along the side of the leaves, or thalli. As you might predict from their small size, each individual plant has a relatively short life span, about two weeks for *Wolffia* and a month for *Lemna*. More background on the *Lemnaceae* can be found at waynesword.palomar.edu/1wayindx.htm.

DISCUSSION QUESTIONS:

What sorts of trade-offs do duckweeds face as a result of their small size and free-floating strategy? What are the advantages and disadvantages? Think in terms of essential resources, physical challenges in the environment, and dispersal.

What sorts of resources would limit the growth of *Lemna* or *Wolffia* populations? Would you expect that interspecific or intraspecific resource competition to be stronger? How might the degree of resource limitation influence population growth and competition?

Preliminary observations

Place a few individual plants in a small petri dish and examine them with a hand lens. Practice counting the number of thalli or individuals. Note that *Lemna* reproduces asexually by buds formed on the side of the parent frond. Think about the best way to quantify population size for this kind of plant.

DESIGNING THE EXPERIMENT

The class will collaborate to design an experiment to compare the effects of interspecific and intraspecific competition the population dynamics of

Lemna and *Wolffia*. To provide a starting point, here are the basic techniques we will use for culturing duckweeds:

- Add artificial pond water to a 2.5cm diameter, labeled test tube, to a mark 2 cm from the top of the tube.
- Place a starting sample of *Lemna* or *Wolffia* in the tube.
- Cover the tube with clear plastic wrap, then poke a few small holes in the plastic wrap.
- Place tube in a rack, and then move the rack to a growth room (18:6 Light:Dark cycle, ~22 C).
- With each count of the system, swirl the water in the test tube (but be sure plants are not left on the side of the test tube).

We will work first in pairs to develop a proposal for the experiment. Then we will establish a protocol for the whole class by consensus. AS YOU DEVELOP YOUR EXPERIMENTAL PROPOSAL, BE SURE TO RECORD THE DETAILS IN YOUR LAB NOTEBOOK. In particular, your experimental design will require several components.

Alternative Hypotheses

Experimental design begins with clearly developed alternative hypotheses. That is, you should not just develop a single, well-reasoned hypothesis, but a set of hypotheses reflecting alternative assumptions about what is going on. Without a clear set of hypotheses, an experiment is just a fishing expedition.

Appropriate Methods

Make sure that your methods match your hypotheses. Ask yourself how they will help you distinguish among the alternatives. Some of the issues that your methods must consider are detailed below.

- Initial Conditions
- Treatments – What Factors Will Be Manipulated and Why
- Replicates – How many per treatment
- Layout – Will factors be randomized? Blocked?
- Measured variables – How do they reflect on the hypotheses?
- Frequency and organization of measurements
    - What information is required?
    - How will the data be organized for analysis?
    - What will reduce the chance that you will forget to include required data?

- Data analysis – the link between data and hypothesis

Interpretations

An experimental design does not just end with hypotheses and methods. You also need to consider the alternative possible outcomes and how you would interpret them in light of your original hypotheses. If different outcomes don't give you direct insights for distinguishing among your alternative hypotheses, your design is not a good one, and it's back to the old drawing board. RECORD YOUR INTERPRETATIONS, ALONG WITH YOUR HYPOTHESES AND METHODS, IN YOUR NOTEBOOK.

Appendix:

What is in "artificial pond water"?

1.3 mM NaCl, 0.8 mM $CaCl_2$, 0.1 mM KCl, 0.2 mM $NaHCO_3$

Supplemental reference:

Lemon, G. D., U. Posluszny, and B. C. Husband. 2001. Potential and realized rates of vegetative reproduction in *Spirodela polyrhiza*, *Lemna minor*, and *Wolffia borealis*. Aquatic Botany 70:79-87.